The origin of the highest-energy cosmic rays - protons and charged atomic nuclei of energies larger than 10^{18} eV - has been judged one of 11 fundamental questions of the 21^{st} century by the US National Research Council. Their sources have remained unidentified since the first detection of an event with energy beyond 10^{20} eV at Volcano Ranch in 1962. Ultra-high energy (UHE) neutrinos, produced by the interaction of ultra-high energy cosmic rays (UHECRs) with cosmic radiation, matter at the source or during propagation in the intergalactic medium, will be a key messenger for the resolution of this enigma. Unlike UHECRs, neutrinos travel unaffected by magnetic fields and thus point directly to their sources of UHECRs, with their production tightly coupled to that of UHECRs.

Progress in this field is largely hindered by the challenging detection of UHECRs and even more so UHE neutrinos, in part since cosmic particles at such energies are detected indirectly through cascades of secondary particles they induce in the atmosphere, called extensive air showers (EAS). Another level of complexity arises from the fact that UHECRs arrive on Earth at a rate of less than 1 particle per km^2 per century at the highest energies, and the flux of their daughter neutrinos is even lower. Furthermore, the interaction cross-sections of the highest-energy neutrinos are extremely small. Gigantic detection areas are hence required to observe these particles and to collect a significant enough number of events. One of the ideas to achieve this goal consists of building ground-based experiments much larger than those currently existing, which already encompass thousands of square kilometres. For this purpose, a new research method is needed, and autonomous detection of radio waves from very inclined UHECRs seems to be the most promising one. It stands behind the Giant Radio Array for Neutrino Detection (GRAND) experiment.

This proposal aims to support the operations of a working group for analysis of GRANDProto300 (GP300) experiment data, which is a pathfinder for GRAND. GRAND, to be completed in the 2030s, will consist of 200,000 radio antennas deployed over 200,000 km^2, while GP300, soon to be deployed in China, will consist of 300 antennas. The main aim of GP300 is developing a fully autonomous system of triggering on the radio signals, as well as reconstructing parameters of very inclined air showers from the radio data only. The latter goal has not been achieved before.

The working group supported by this grant focuses on the rejection on off-line signal identification, as well as the reconstruction of parameters of the cosmic ray induced extensive air showers such as Xmax (the part of the EAS with maximum content of charged particles), energy, and direction of origin. The research outlined in this proposal is crucial for the following phase of the GRAND experiment. Deploying 10,000 antennas for GRAND10k, expected around 2025, will initiate the search for ultra high energy neutrinos.